sPhenix Tracking Performance Simulations

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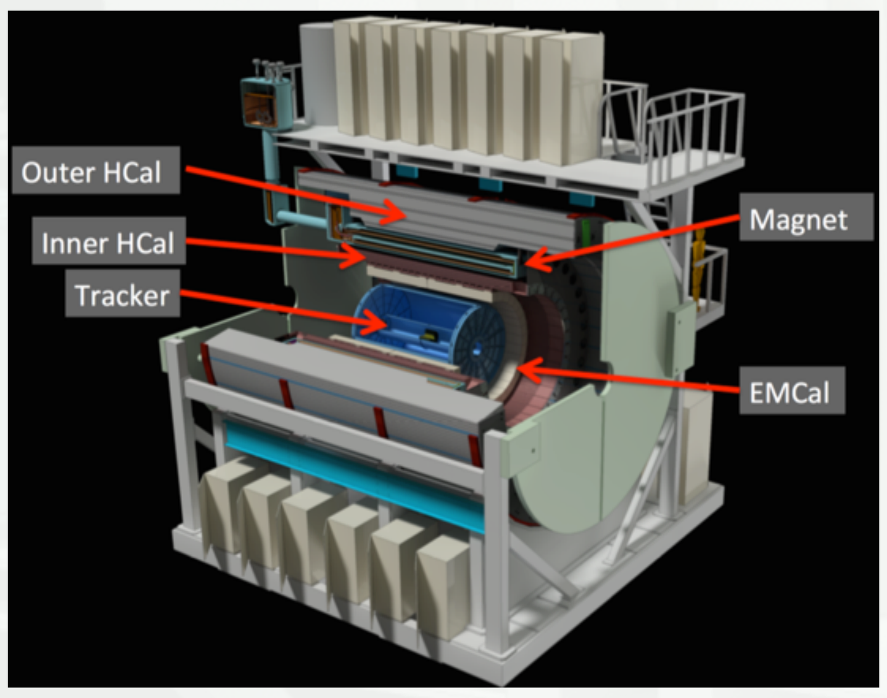
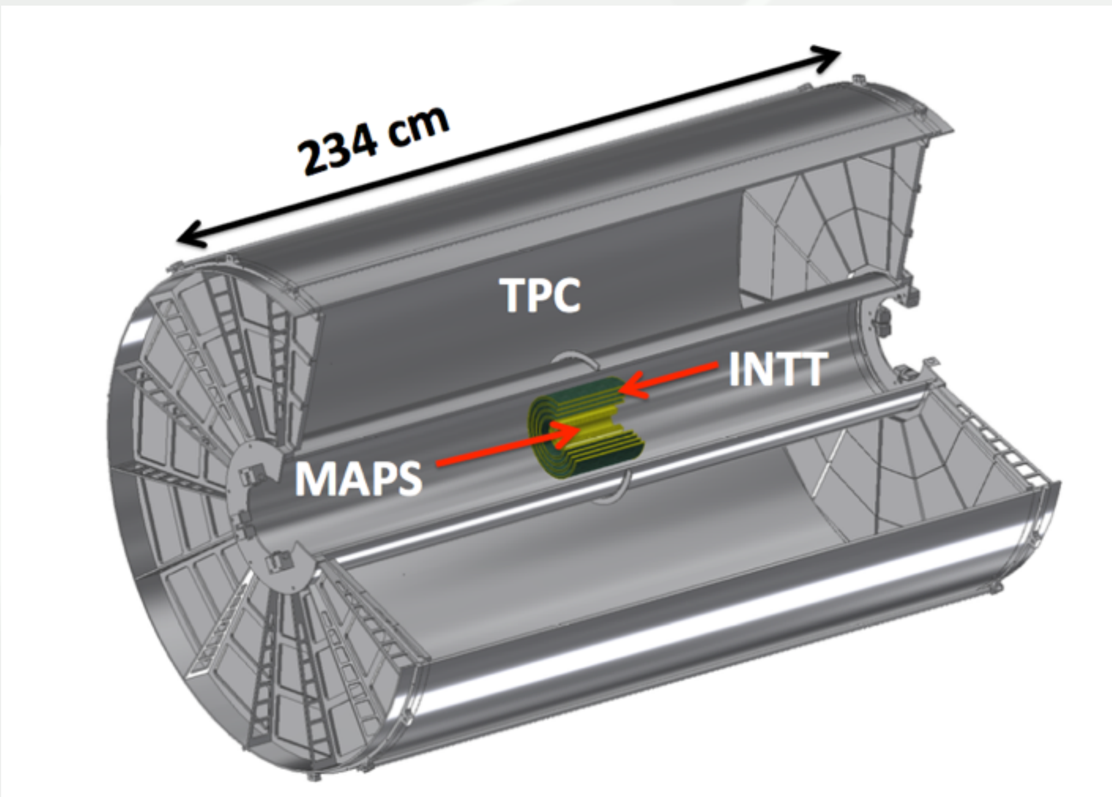
Introduction

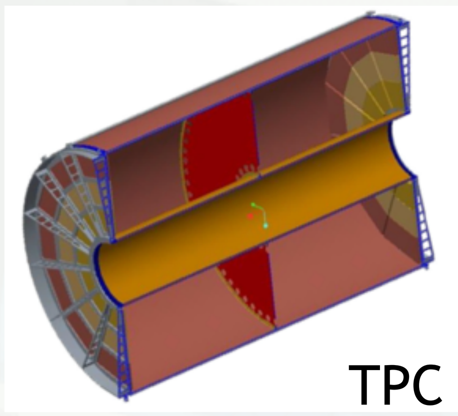
sPHENIX is an upgrade to the PHENIX detector proposed to explore the quark-gluon plasma formed in heavy ion collisions through measurements of jets and upsilons at RHIC in the 2020's. The experiment will feature a 1.4 Tesla superconducting solenoid magnet which was formerly used by the BaBar experiment. A charged particle tracking system will be placed together with an electromagnetic and hadronic calorimeters spanning full azimuthal coverage and 2 units of central pseudo-rapidity. The tracking system will consist of a Time Projection Chamber (TPC) with a GEM-based readout, an intermediate silicon strip tracker (INTT), and a MAPS (Monolithic Active Pixel Detector) micro-vertex detector.

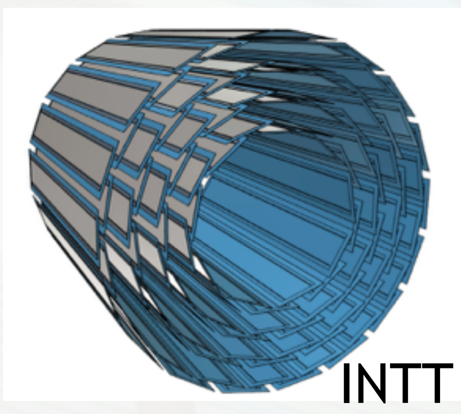


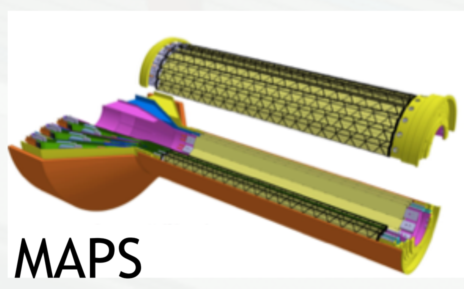
Tracker Description

- Track reconstruction over 2π, $|\eta| < 1.1$, 0.2 GeV $< p_T < 40$ GeV
- Outer radius constrained by EMCal geometry, $R_{outer} < 78$ cm
- Inner radius constrained by beam pipe, $R_{inner} > 2.1$ cm
- The tracker consists of three detector subsystems that provide primary and secondary vertex, pattern recognition and good momentum resolution:
  - TPC: Continuous readout (R = 20-78 cm)
    - Gas used will be Ne-CF4-iC4H10 "Ne2K"
  - INTT: 4 layers Si strip (R = 6, 8, 10, 12 cm)
  - MAPS: 3 layers vertex tracker (R = 2.3, 3.1, 3.9 cm)









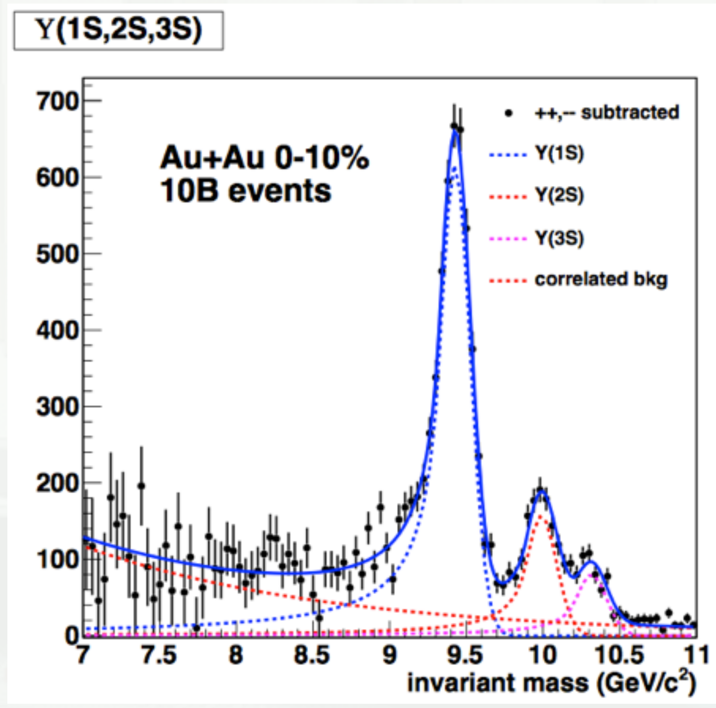
TPC: poster by Klaus abstract #716;Takao, #723; Sourav, #710
INTT see poster by Gaku abstract #705
MAPS see poster by Cesar daSilva abstract #706

Tracking Simulation

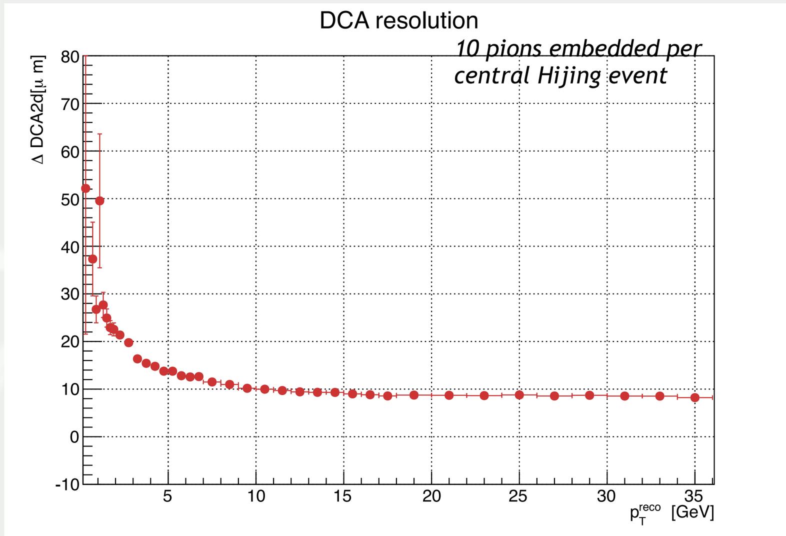
- Geant4 hits → ADC digitization of cell
- Geant4 hits → Removal of low energy hits
- Geant4 hits → Clustering of cell hits
- Clusters → Removal of low energy clusters
- Tracks → Hough transform to find tracks in helix parameter space
- Tracks → Kalman filter to fit tracks
- Tracks → Ghost rejection with χ^2

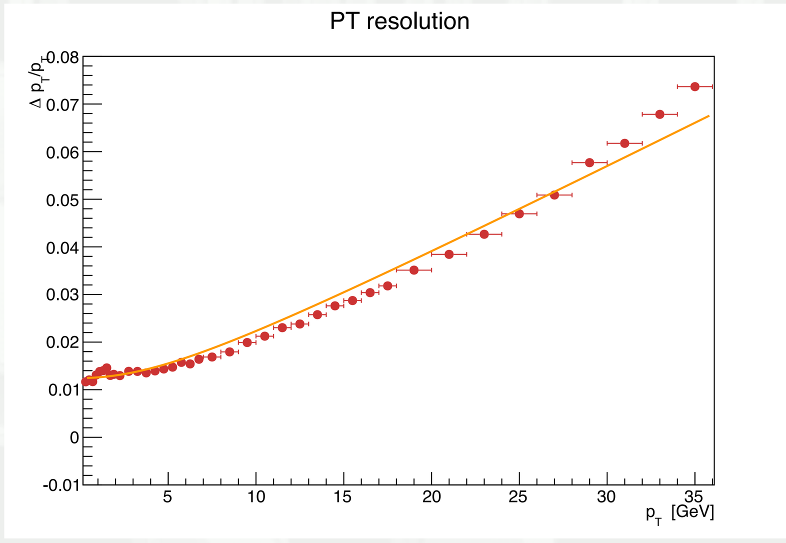
Resolution

- We need a very good resolution between 0.2-10 GeV and acceptable resolution at high p_T to have a good upsilon mass resolution and a full characterization of jet final state.
- Excellent displaced vertex (DCA) resolution enables b-tagging of jets (*see poster by Hawing abstract #726*).



see poster by Krista abstract #707





Efficiency and Purity

- *Reconstructable*: G4Truth that deposites energy in at least 25 TPC clusters.
- *Fair-track*: track that match to a MCTruth with more than 25 contributed clusters.
- *Good-track*: track with χ^2 / NDF < 2 and TPC clusters > 25

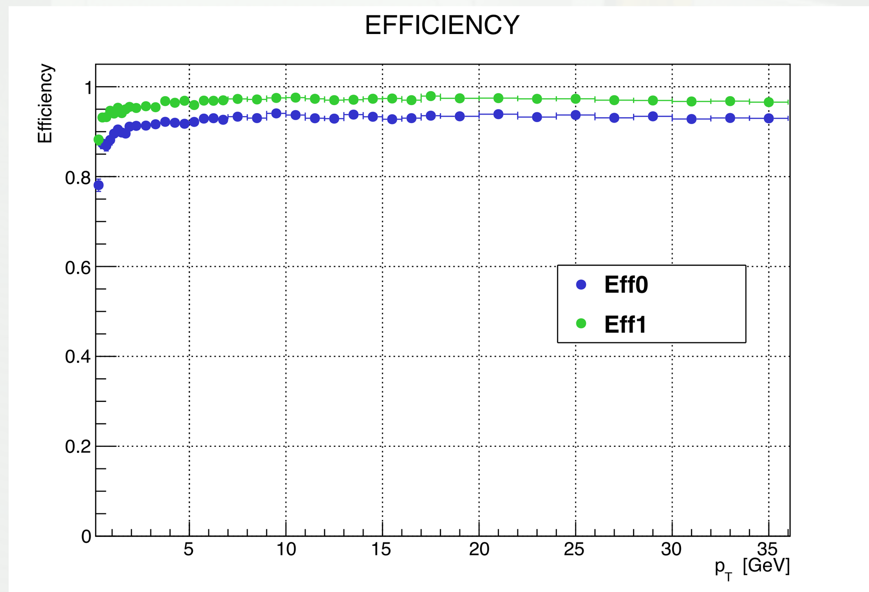
- Maximum achievable efficiency

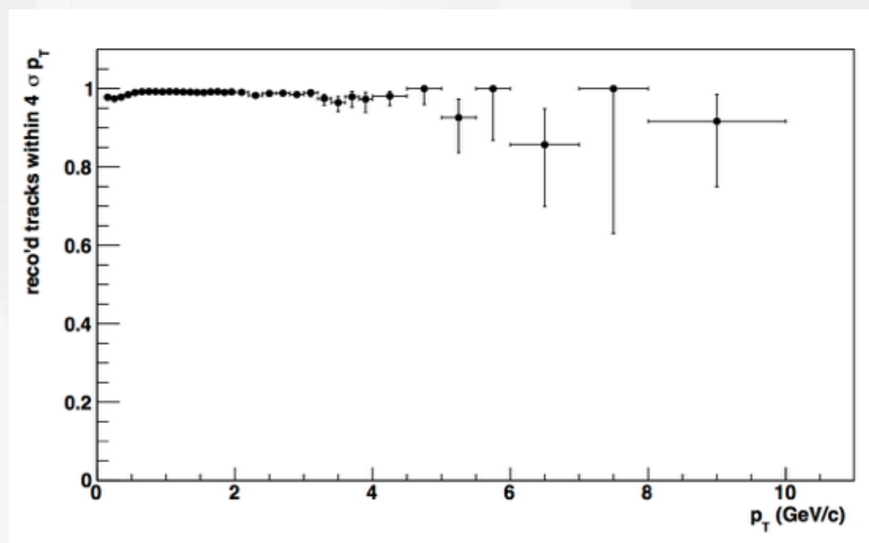
$$\text{Eff0} = \frac{\text{G4particles matched to } \textit{fair-track}}{\text{Reconstructables}}$$

- Efficiency of current tracking software

$$\text{Eff1} = \frac{\text{Good-tracks with } p_T \text{ within 4 sigma}}{\text{Reconstructables}}$$

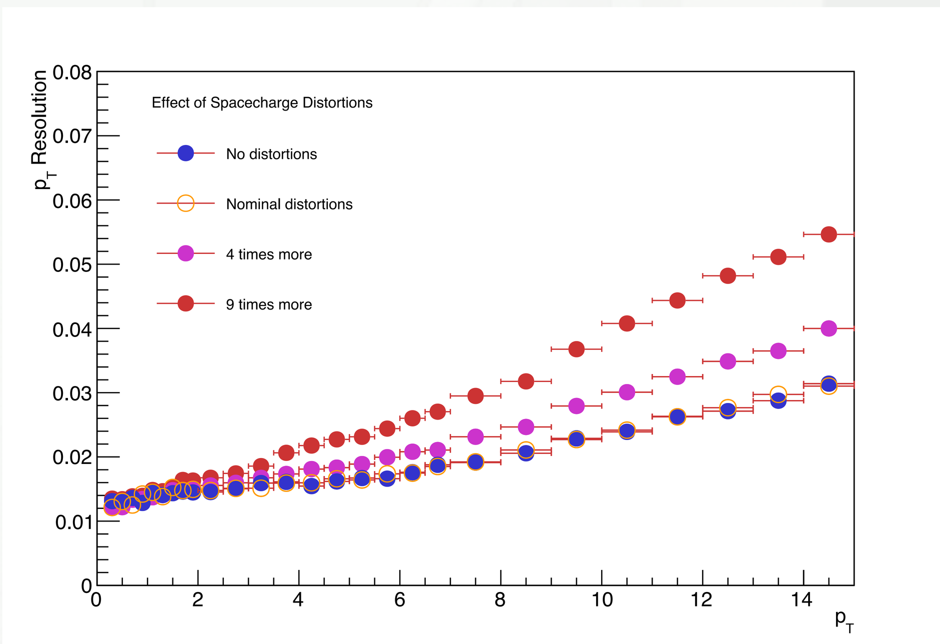
$$\text{Purity} = \frac{\text{Good-tracks with } p_T \text{ within 4 sigma}}{\text{Good-tracks}}$$





Spacecharge Distortions

- Positive ions in the TPC volume create space charge that distorts the apparent hit position.
- The space charge distortions affects mostly the resolution. The efficiency and DCA resolution changes are very small.
- Space charge distortions have been implemented in simulation with:
  - a smear proportional to distortion
  - a shift proportional to distortion
  - have been tuned with the ALICE values of IBF.



see poster by Prakhar abstract #715

Summary

- PHENIX tracking is key for the physic program: Upsilon, Jets and Open Heavy-Flavor.
- Combination TPC with MAPS and INTT delivers excellent performance:
  - Very good momentum resolution at low p_T for Upsilon mass studies.
  - Good momentum resolution at high p_T for jet substructure studies.
  - Good DCA resolution for b-jet studies.
  - Excellent pattern recognition in central Au+Au Hijing events.
  - Single tracker efficiency higher than 90% .